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gions. Of the former character are *Spea, Phrynosoma, Barissia, Gerrhonatus, Hypsiglena* and *Salvadora;* of the latter kind, *Spelerpes, Liolepisma, Osceola, Storeria* and *Systrurus.* Characteristic of Medicolumbia generaly: *Amblystoma, Rana, Sceloporus, Eumeces, Diadophis, Eutænia, Crotalus.* Peculiar genera:

Siredon,	*Hemigenius,*
Thorius,	*Epiglottophis,*
Malachylodes,	*Ogmius,*
Conopsis,	*Ophryacus.*

Neotropical genera: *Oedipus, Anolis, Celestus, Atractus, Ninia, Drymobius, Bothriechis.*

(*To be continued.*)

FOSSILS AND FOSSILIZATION.

By L. P. Gratacap.

I.

A fossil, in Paleontology, is any indication of life which has become entirely or partially altered in its substance or condition by the mineral or chemical agencies of its environment. As an " indication " it embraces the widest possible series of remains which have, or could have, any connection with living organisms, from the bones of a vertebrate, the hard parts of an invertebrate, the foliage, fronds, seeds and wood of plants, to the fillings of worm burrows, the tracks of insects, reptiles, mammals, mollusca and crustaceans, and those problematic impressions which have been referred to Medusa, or those by Prof. Hall to the soft parts of an Orthoceras. And it also includes the stony casts formed by the entrance of extraneous mud or silt, sand or chemical deposits within the hard parts of animals upon their death and the disappearance of the soft parts by decay. The hard parts, upon removal by solution, leave the impressions of their interior upon this soft filling which faithfully copies the contour and size of the organism.

These casts form a large group of fossils, and sometimes afford most important information as to the vascular markings and muscular tissues of both crustaceans and brachiopods, though they often perplex the paleontologist by their meagre and unsatisfactory characters. Again, the moulds of exteriors, the phase of preservation complementary to casts must be classed with "fossils." Such impressions often present the superficial ornamentation of shells, and by filling them with soft material as sulphur, wax, or rubber, a reproduction of the original organism in size and form can be satisfactorily obtained. The application of the word "fossil" may be even extended to designate those doubtful evidences of organic life, such as the mixture of the minerals, serpentine and calcite, which have yielded, upon microscopic inspection, some suggestions of organic structure, and with which the famous name of *Eozoon* has been associated, and over which a notable controversy exists to-day. However the term "fossil" is used, its exact meaning from *fodeo* to dig, refers to the most common circumstance connected with the search for fossils, *viz.*: the excavation of rocks or earth, and hence, literally, a *fossil* is a thing *dug out*, implying a past stage of existence in which it has undergone burial and hinting at its subsequent exhumation. This association has no invariable applicability. Fossils are found exposed upon ancient beaches very slightly covered, as in the shell beds at Beauport, New York, where the valves of *Saxicava rugosa*[1] "form a bleached white mass, twelve feet thick, perfectly stratified, and with only sufficient sandy matter to form the lines of division between the strata" (E. Emmons, Geol. N. Y., Pt. IV, p. 129); they are spread upon the surface of wide extents of territory as in parts of Syria where thousands of cardiums, in the form of casts, are seen upon the road and in the fields, from which wagon-loads could be secured, though not a fragment of a shell or a piece of a hinge-tooth, for purposes of identification, are visible (O. Fraas, Aus dem Orient, Pt. II, p. 73). Similarly, in the cretaceous beds of Texas in the neighborhood of Neu Braunfels, Exogyras and Gryphaeas, are thickly strown over the ground, disengaged by sub-aerial weathering and surface waters from their enclosing marls (F. Roemer, Kreidebildungen von Texas, etc., p. 14, et seq.). Indeed, under some circumstances inhumation quickly destroys fossil remains from the acidic qualities of the soil, as in the neighborhood of Cumanacoa, Venezuela, S. A., as reported by Humboldt[2] (Travels in Equinoctial Regions of America, Vol. I, p. 228, Bohn's Edit.), and we think that, in many instances, fossils have undergone silicification more rapidly when brought under surface conditions where exposed to mineral waters, than they would have if covered in completely, and so removed from the influences of terrestrial circulation.[3]

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[1] A Lamellibranch or bivalve shell now found living along our coast, from Georgia to the Arctic Ocean; very common from Massachusetts Bay to Labrador, occurring from low-water mark to 50 fathoms or more.

Yet the word *fossil* is, of course, a distinct reference to a creature living in the past, and, as such, very properly implies entombment of some sort, and, as a fact, fossils are generally embedded in rocks or alluvial and diluvial beds, in clay banks or thinly aggregated beach sands. They may be subsequently exposed by weathering and by removal, but they indicate some sort of initial burial. Their chronological significance indicating the successive phases of animal life in geological time implies a stage-like superimposition with the earliest fossils at the bottom and the latest at the top. As, in fact, such superimposition is only partially, and then locally, perfect—no section of the earth's surface revealing a sheer and consecutive ascension of all the known strata, containing fossils—we constantly find the fossil-bearing rocks forming the surface of wide regions, and many fossils are in a more desirable condition, as specimens for study, when surface weathering has revealed them from the matrix and brought them into a clean and significant relief, as in the case of chain corals (*Halysites catenulatus*) in the Niagara Limestone of western New York, or when the solvent of carbonated waters has left them accessible, in a friable and open ferruginous sand, as in the weathered rinds and exteriors of the siliceous limestones of the Schoharie Grit of eastern New York.

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[2] Dr. Schwernfurth, in his "Heart of Africa," mentions a soil in which the natives bury their drums, stools, etc., "to give them a permanent blackness." The vegetable acids developed by decomposition in such areas would act more or less corrosively on bone. Mr. J. Richardson tells me that in one year the entire carcass of a cat buried in rich soil had completely disappeared. On the other hand, "the fossil bones of the megatherium of the elephant and of the mastodon, which travelers have brought from S. A., have all been found in the light soil of the valleys and table-lands." Humboldt.

[3] Dr. Otto Kuntze (Nature, Vol. 19, p. 314) has insisted that his observations show that silicified trunks of trees "originate only in air; the siliceous water rises by capillary attraction in the stem, but only on the outside of the trunk does the siliceous solution become solid by drying in the air; from the outside the silicification of the wood cells enters verv slowly to the inner part."

Fossils represent the hard parts of animals or such portions of their soft parts as have become replaced by mineral materials. The fleshy organic elements of an animal undergo decomposition and disappear, even though enclosed in sediments of great thickness. Water-carrying oxygen finds its way around them and slowly introduces those putrefactive changes which result in disintegration and solution. But in this process, if it is prolonged, there is a substitution of earthy matter, and an infiltration of silt will assume the form of muscular bands, retain the outline of muscular scars and blood-vessels, while a more obscure course of substitution may slowly replace the chitinous, horny, or even fleshy, appendages with silica, iron pyrite, and other mineral species, preserving them with microscopic fidelity. Many forms of animal life, like the Medusæ, Ctenophoræ, Holothurians and Worms, from their soft consistency, are necessarily almost excluded from a representation amongst fossils, being, at the best, only indicated by impressions. The occasional and unusual preservation of the fleshy parts of extinct animals in ice can hardly be regarded as a contradiction of this universal rule.

The various stages of the natural process by which organic beings become fossils[4] may be conveniently regarded as three —first, the *placement* of the object in its position preparatory to fossilization; second, its sepulture or burial, and third, the mineralogical or chemical changes by which it assumes its permanent form or condition as a fossil. The history and discussion of these three steps form a complete history of fossilization.

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[4] The word "fossil" receives a curious application by old writers, especially by the celebrated Werner, who used it to designate any mineral object extracted from the surface of the earth. Thus minerals become fossils, and he speaks of "'solid fossils," and he divides them into "hard, semi-hard, soft, and very soft." Also see Pinkerton's Petrology.

The placement of an object will vary in its conditions, according to the habitat of the organism. The most general distinction will be between terrestrial (for the most part, vertebrates) or marine (for the most part, invertebrates) organisms, where the contrasted conditions involve contrasted habits and varying accidents and associations. Upon the surface of the land animals may die in numbers, either upon plains or elevated regions, or in the depths of forests, but the rapid action of decay, or the ceaseless activity of flesh-eating insects may soon dissipate their remains, even when the bony skeleton is imposing and highly developed.

The bones of buffalo remain upon the western prairies for four or five years, at least, in a recognizable condition.[5] In the region about Miles City, Montana, the buffalo abounded as late as 1880. After that time, the remorseless zeal of hunters and the avarice of trade had reduced their numbers and brought them to the verge of extinction. According to W. T. Hornaday, "over the whole of this vast area their bleaching bones lie scattered," and many of these have certainly been exposed to the weather for a period of four years, while their condition when collected warranted the expectation of their remaining sensibly unchanged many more. (See the Extermination of the American Bison, Smithsonian Report, 1887, p. 508.)

Upon the visit of the Challenger to Hard Island, of the McDonald Group in the Antarctic seas, Prof. Moseley observes that upon a sandy glacial plain there were strown "bones of the sea-elephant and sea-leopard, those of the former being most abundant. There were remains of thousands of skeletons, and I gathered a good many tusks of old males. The bones lay in curved lines, looking like tide-lines, on either side of the plain above the beaches, marking the rookeries of old times, and teaches of slaughter of the sealers. Some bones occurred far up on the plain, the elephants having, in times of security, made their lairs far from the water's edge. A few whales' *vertebræ* were also seen lying about." In dry or temperate regions, bones resist disintegration indefinitely.

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[5] It is interesting to note that Captain Stansbury observes in his Exploration and Survey of Great Salt Lake, that "carcasses of buffalo left on the open prairie are not unfrequently completely cured, or rather 'mummified' in the sun, so that they seldom exhibit any sign of decay."

In Canada, at Helena, a vast collection of thousands of buffalo skulls are seen, the enduring vestiges from a slaughter of wild buffalo surrounded by Indians at that place.

The structure of bone in exposures where the climate passes through severe extremes is an element of weakness in their preservation. Winding canals (Haversian canals) traverse the substance of hard bone and secure connection with a series of lacunae, distributed through the substance of the bone, by means of minute tubuli (canaliculi). These tubuli radiate in complex tangles from the lacunae. Sarcodic or marrow-like matter permeates these delicate passages, and, in the Haversian canals, blood corpuscles circulate. In the less dense portions of bones, as the extremities of the leg- and arm-bones, head-bones, etc., a cancellated or cellular structure forms a porous area, while long cavities (marrow-cores) filled with marrow occupy the axes of the longer bones. The decomposition of these organic contents at first weakens bone, and commences an insidious process of splitting. Subsequently the bone becomes filled with water, and the labyrinthine chain of chambers, small and large, are saturated. Cold succeeds, and from the expansion produced by frost the bone is shivered with an incalculable number of microscopic rents. These increase until cohesion is overcome and the bone falls apart.

The mammalian remains may also be placed in soft and water-saturated districts, as swamps and estuaries, lake sides and spring bottoms, whither animals have been attracted by supplies of water or because herbage and prey were equally abundant. Bones and osseous remains of vertebrates buried in rich carbonaceous soil must, to some extent, yield to the corroding action of organic acids. The important roll played by organic acids as agents of decomposition has been recognized. The numerous orders of oxygenated compounds known as acids, and which result from the accumulation of vegetable matter in fermentable masses, have come to be regarded as most universal and persistent in their influence. It has been shown by Dr. H. C. Bolton that organic acids may be successfully employed for the detection and separation of mineral species, and Dr. A. A. Julien (Proc. A. A. A. Sci., 1879) has gathered together in a comprehensive review such inferences of their geological action as observation of their influence to-day permits. These acids[6] dissolve iron salts and effect disintegrating effects upon hydrated or soluble quartzes. Such active and omnipresent agencies must exert a very appreciable influence upon animal remains, and in conjunction with carbonated waters must render their preservation precarious. Terrestrial vertebrates, whose remains in the soil of forests or grassy plains would be exposed to the injurious attacks of these vegetable extracts and products, would run some considerable risk of being destroyed.[7] The *placement* of such fossils must be somewhat modified for their effectual integrity. It is true that swamps in whose periods of existence many successions of spagnum layers with the associated accumulation of related and contemporary plants have stored up great quantities of organic debris, have been the repositories of bones, and the great vertebrates, whose bones have become inhumed in their acid-laden depths, have been extracted in a reasonable state of preservation. But it is also true that these heavy bones have worked their way down through the superficial and organic layers to clay marl and sandy bottoms, where they were largely protected from the corrosive action of the humus acids which infiltration and drainage of surface waters would have partially removed.

[6] The vegetable or organic acids are mainly humic, crenic, apocrenic, with which there is an adventitious mixture of oxalic, malic, acetic and fumaric acids, which, according to Julien, are introduced "at least temporarily by the leaves, stems, etc., of most plants, many of which are rich in raphides made up of minute crystals of these acids or their salts."

[7] It is a matter of common knowledge that the bones of goats swallowed by boas undergo solution in the animal acids of their host, so that the calcareous exuviae scarcely equals a tenth part of the original mass of bones, while the so called *album graecum* in the faecas of dogs, hyaenas, etc., represents the residue of digested bones.

The Warren mastodon found at Newburgh, N. Y., in 1845, was embedded in a bed of shell-marl, above which rested a layer of red moss, over which, upon the surface, spread a "thickness of two feet of peat-bog." This specimen was in a very perfect state of preservation, revealing almost the entire skeleton of *M. giganteus.* The Cambridge mastodon was also in an admirable state of completeness, though the nature of the enveloping matrix seemed less favorable. This specimen was taken out at Hackettstown, Warren Co., N. Y., in 1845. The character of the deposit in which it was buried was distinctly organic, consisting of one foot of decayed leaves, six inches of whitish sand mixed with vegetable matter, and a yellow layer, resembling manure, offensively odorous. It would seem a reasonable inference that this large quantity of plant debris would have been unfavorable for the perfect preservation of the bones, and that the organic acids resulting from its decomposition would have aided in their removal. Of course, any protection from the air by the overlying seal of earth, clay, or water, would retard and prevent the oxydation by which the elements of cellulose become converted into acids; and bones immersed in vegetable remains under such circumstances may remain, as practically in this case, exempt from the dissolving agencies of vegetable acids. The Cohoes mastodon, found at Cohoes, N. Y., was taken from a river pothole, into which the remains had been carried, and was surmounted by vegetable debris, but had lodged upon an underlying bed of marl and comminuted shale. This skeleton was in excellent condition.

The Ward mastodon, now at the American Museum in New York City, was found at Newburgh, N. Y., in a swampy wet corner of a potato field, and was in a fair state of preservation.

Commenting upon the position of such vertebrate remains, Dr. Warren says: "In nearly all these different spots, the bones have lain at the depth of from five to ten feet below the surface. The same fact is true of deposits near Niagara, described by Sir Chas. Lyell; of those in Virginia, Long Island, the salines of Ohio, Kentucky, and most other places in the western and southern country of the United States.

"The overlying deposits are generally a foot or two of mud, the same thickness of clay, a layer of peat sometimes intervening, and below the clay shell-marl containing everywhere the relics of fresh-water testacea of existing species; some of them perfect, others decomposing. Sir Chas. Lyell, in his geological tour through the State of New York, found at Genessee, the bones of the mastodon in a bed of shell-marl below the peat, corresponding, he remarks, with the situation of the fossil elks of Ireland, generally considered to have been buried in bog-mud or peat swamps, but which, in fact, lie in a stratum of shell-marl."

It seems probable that the enormous quantities of moa bones found in the turbary area at Glenmark, New Zealand, afford some grounds for questioning the destructive influence of vegetable acids. According to Dr. Von Haast,[8] a large swampy tract in Glenmark, covering a depressed region and partaking of the mingled characters of an estuarine and lacustrine basin, contains an incredible number of the skeletons of these great birds. The bones occur here in separated patches or nests, and the impression, made by their distribution, is that of a sudden flight of groups of the birds over this marshy delta which has sunk in places beneath them, and thus entrapped them in constantly increasing numbers. Bones of twenty or thirty individuals, of all sizes and ages, and lying closely packed in spots about five or six feet in diameter, are found with no bones near them, as if, at particular points, the birds had disappeared, one after another, in the enveloping mass of vegetable dêbris and soft mud. Evidences here are everwhere pleutiful of successive freshets by which accumulations of trees, seeds, stems and drift timber have been formed, which, with the growth of bog plants, created a deep vegetable blanket in which the moa bones are immersed. Four to seven feet of pure black peat are succeeded by two to three feet of more impure peat, in which the bird bones are more commonly laid, and under these a hard clay bottom completes the section. It would seem reasonable to expect a plentiful production of humic acid and its allied compounds under these circumstances, and if, as Julien asserts, these acids attack the phosphates of alkaline earths (phosphates of alumina lime and magnesia), the preservation of the moa bones appears either exceptional or contradictory.

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[8] Geology of Canterbury and Westland, New Zealand, J. Von Haast. See also Ann. & Mag. Nat. Hist., Aug., 1844, Rev. W. Colenso; Transac. New Zealand Inst., Vols. IV, VI, J. Von Haast.

In this connection it must be remembered that in all such vegetable infusions a considerable amount of tannin must accumulate, and its astringent action upon the gelatine of bone has a tendency to protect the bone along the interior walls of its cavities and canals. Lyell is at some pains to illustrate, in his Principles, Vol. II, pp. 508–510, the preservative properties of peat, but these illustrations relate more to its antiseptic properties for the preservation of animal tissues. Thus, in a peat-moss in the Isle of Axholm, Lincolnshire, Scotland, a body of a woman was preserved six feet below the surface; bodies of two persons in Derbyshire, England, were kept quite uninjured in moist peat, and pigs were found intact in a peaty soil near Dubuerton, Somersetshire.

There is also a possibly protective action exercised at times by the organic acids themselves when they concentrate upon a nucleus of bony fragments, precipitates of iron oxide or amorphous silica. This is done by their reduction of iron salts forming organic compounds, or by combination with silica in the dissolved silica of the infiltrating streams. The iron is liberated from solution by oxydation and the silica by decomposition, and both iron oxide and soft silica may be thus introduced into the interstices of the bone and serve as agents of induration. It is said by Von Haast that the moa bone layer at Glenmark is somewhat reddish. This may be attributed to ferruginous encrustations. Again, the action of organic acids on such material as the harder class of bone must be somewhat limited by dilution, and the constant percolation of water from surface water-courses and rains must considerably neutralize the corrosive power of the readily dissolved vegetable fluids. Again, these vegetable fluids are quite liberally employed in making defensive combinations with the mineral matter brought to them in complete solution or mechanically suspended in the streams passing over and through marshes, swamps, bogs and deltas, and are so divested of any destructive power upon bone. And in any case, the elaboration of these acid products which we are considering would be partial or completely suspended at such depths as are usually given for the repositories of vertebrate remains. Yet, however diverted or minimized may be the action of organic acids and carbonated water upon bone, there can be little doubt that it is considerable, and an important means in many cases of imparting to them much fragility or of entirely disintegrating them.

(*To be Continued.*)

THE BACTERIAL DISEASES OF PLANTS: A CRITICAL REVIEW OF THE PRESENT STATE OF OUR KNOWLEDGE.

By Erwin F. Smith.

(*Continued from p. 804*)

IV.

II. THE HYACINTH (HYACINTHUS ORIENTALIS).

(II) The organism: *Bacillus hyacinthi* (Wakk.) Trev. (1883).

1. *Pathogenesis:*
   - (A) Yes.
   - (B) Yes (?). The poured plate method was not then in general use. Inoculations were made directly from diseased plants into sterile nutrient fluids, or into tubes of nutrient gelatin, and the resulting cultures may not always have been pure ones, although the writer's own experience has shown conclusively, in case of melon wilt—a somewhat similar disease—that it is often possible to obtain pure cultures in this way, if the culture